Machine learning may be a game-changer for climate prediction

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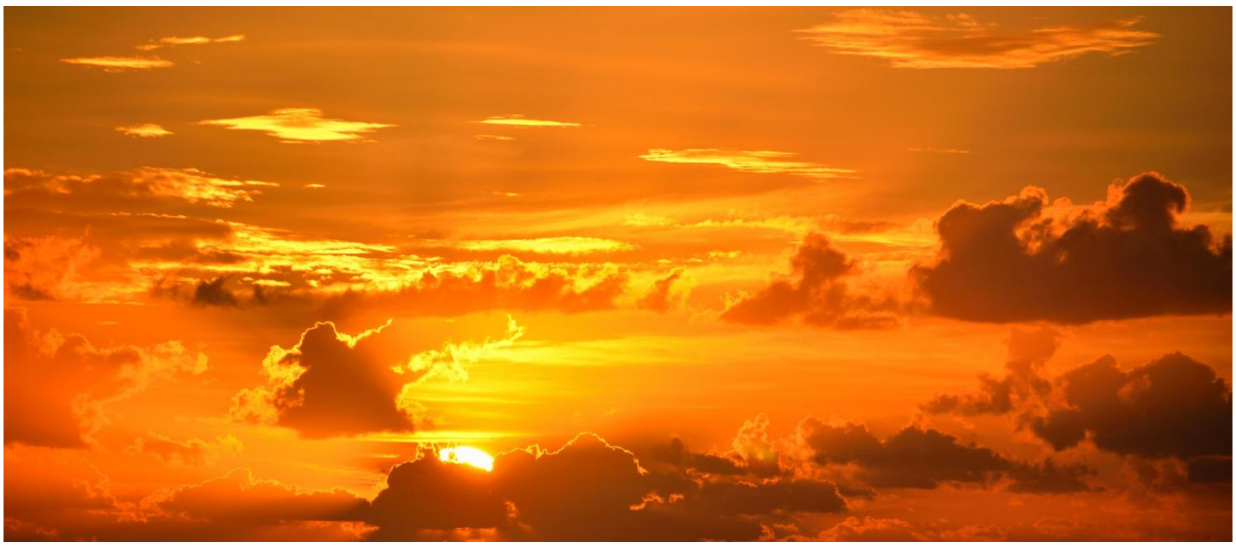

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A major challenge in current climate prediction models is how to accurately represent clouds and their atmospheric heating and moistening. This challenge is behind the wide spread in climate prediction. Yet accurate predictions of global warming in response to increased greenhouse gas concentrations are essential for policy-makers (e.g. the Paris climate agreement).

In a paper recently published online in *Geophysical Research Letters*, researchers led by Pierre Gentine, associate professor of earth and environmental engineering at Columbia Engineering, demonstrate that machine learning techniques can be used to tackle this issue and better represent clouds in coarse resolution (~100km) climate models, with the potential to narrow the range of prediction.

"This could be a real game-changer for climate prediction," says Gentine, lead author of the paper, and a member of the Earth Institute and the Data Science Institute. "We have large uncertainties in our prediction of the response of the Earth's climate to rising greenhouse gas concentrations. The primary reason is the representation of clouds and how they respond to a change in those gases. Our study shows that machine-learning techniques help us better represent clouds and thus better predict global and regional climate's response to rising greenhouse gas concentrations."

The researchers used an idealized setup (an aquaplanet, or a planet with continents) as a proof of concept for their novel approach to convective parameterization based on machine learning. They trained a deep neural network to learn from a simulation that explicitly represents clouds. The machine-learning representation of clouds, which they named the Cloud Brain (CBRAIN), could skillfully predict many of the cloud heating, moistening, and radiative features that are essential to climate simulation.

Gentine notes, "Our approach may open up a new possibility for a future of model representation in climate models, which are data driven and are built 'top-down,' that is, by learning the salient features of the processes we are trying to represent."

The researchers also note that, because global temperature sensitivity to CO_2 is strongly linked to cloud representation, CBRAIN may also improve estimates of future temperature. They have tested this in fully coupled climate models and have demonstrated very promising results, showing that this could be used to predict greenhouse gas response.

More information: P. Gentine et al, Could Machine Learning Break the Convection Parameterization Deadlock?, *Geophysical Research Letters* (2018). DOI: 10.1029/2018GL078202

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